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Aeronautical Telecommunications Using IPv6

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What is IPv6?

- IPv6 is short for "Internet Protocol Version 6". IPv6 is the "next generation" protocol designed by the IETF to replace the current version Internet Protocol, IP Version 4 ("IPv4").
- Most of today's internet uses IPv4, which is now over twenty years old. IPv4 has been remarkably resilient in spite of its age, but it is beginning to have problems. Most importantly, there is a growing shortage of IPv4 addresses, which are needed by all new machines added to the Internet.
- IPv6 fixes a number of problems in IPv4, such as the limited number of available IPv4 addresses. It also adds many improvements to IPv4 in areas such as routing and network auto-configuration. IPv6 is expected to gradually replace IPv4, with the two coexisting for a number of years during a transition period.

IPv6 for Aeronautical Use

- Meets Safety and Security Requirements
- Offers High Availability
- Provides an Affordable Platform
- Is Robust and Scalable
- In use today and is the Internet protocol of the future

Aeronautical Applications

- Ground-Ground Networks
- Air-Ground Communications
- Onboard Networks
  - Avionics
  - Administrative
  - In Flight Entertainment
  - Passenger devices

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IPv4 and IPv6

- IPv4 is not considered to have any major flaws
- IPv4 addresses limited to 32 bits, good in 1978 but insufficient today
- IPv6 developed between 1992 and 1996
- IPv6 increases addressing to 128 bits and incorporates 20+ years of lessons learned
- IPv4 and IPv6 are expected to coexist

IPv6 Features

- New header format
- Large address space
- Efficient and hierarchical addressing and routing infrastructure
- Stateless and stateful address configuration
- Built-in security
- Better support for QoS
- New protocol for neighboring node interaction
- Extensibility
- Router (Network) and End-System Mobility

New Header Format

- Keeps overhead to a minimum
- Moves non-essential fields and optional fields to extension headers
- Streamlined header is more efficiently processed by routers
- IPv6 headers are only twice as large as IPv4 even though addresses are four times as large
- IPv4 and IPv6 headers are not interoperable
- Routers must today implement IPv4 and IPv6

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Large Address Space

- IPv6 has 128-bit (16-byte) source and destination IP addresses
- 128 bits can express 3.4×10^{38} combinations
- IPv6 addresses allow multiple levels of subnetting and address allocation
  - Not all of the 3.4×10^{38} addresses will be usable due to aggregation
- Network Address Translation (NAT) is no longer necessary

Efficient and Hierarchical Addressing and Routing Infrastructure

- IPv6 global addresses create an efficient, hierarchical and aggregatable (summarizable) routing infrastructure
- Address architecture based on common occurrence of multiple levels of Internet Service Providers
- Internet backbone routers have much smaller routing IPv6 tables than those for IPv4

Stateless and Stateful Address Configuration

- Nodes will have multiple addresses
  - Loopback
  - Link-local unicast
  - Global unicast
  - Site-local unicast
  - Multicast
- Stateful – assigned by a DHCP server
- Stateless – created in the absence of a DHCP server
  - Address derived from router advertisements
  - Auto-configured link-local addresses even when a router is not present

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Built-in Security

- Support for IPSec is mandatory for IPv6
  - Provides a standards-based solution for network security needs
  - promotes interoperability between different IPv6 implementations

Better Support for QoS

- New fields in the IPv6 header define how traffic is handled and identified
- Traffic identification by routers uses a Flow Label field in the IPv6 header
- QoS can be achieved even when the packet payload is encrypted

New Protocol for Neighboring Node Interaction

- Neighbor Discovery for IPv6 is a series of messages that manage the interaction of nodes on the same link
- Neighbor Discovery using unicast and multicast replaces the broadcast-based IPv4 Address Resolution Protocol (ARP), IPv4 Router Discovery and IPv4 Redirect messages

Extensibility

- New features can be added using extensions headers after the IPv6 header
- Unlike IPv4 headers with a 40-byte option limit, IPv6 is constrained only by the IPv6 packet size

Differences Between IPv4 and IPv6 (Part 1 of 3)

32-bit source and destination addresses	128-bit source and destination addresses
IPSec is optional	IPSec is required
No identification of packet flow in header	Packet flow identification standard in header (QoS)
Fragmentation done by both routers and hosts	Fragmentation done only by hosts
Header includes a checksum	Header does not include a checksum

Differences Between IPv4 and IPv6 (Part 2 of 3)

Header includes options	All optional data is moved to IPv6 extension headers
ARP uses broadcast messages to resolve link layer addresses	Neighbor Solicitation messages are used
Internet Group Message Protocol (IGMP) used to resolve local subnet group membership	Multicast Listener Discovery (MLD) is used
Router Discovery is used to determine default gateway	Router Solicitation and Router Advertisement messages used (and required)
Broadcast addresses are used to send traffic to all nodes on a subnet	No broadcast messages used. Link-local scope all-nodes multicast is used

Differences Between IPv4 and IPv6 (Part 3 of 3)

Addresses must be configured manually or through DHCP	No manual or DHCP required
Uses Domain Name Service (DNS) host address (A) records	Uses DNS host address (AAAA) resource records
Uses pointer (PTR) records in IN-ADDR.ARPA domain to map addresses to host names	Uses pointer (PTR) records in IP6.ARPA domain to map addresses to host names
Must support a 576-byte packet size (possibly fragmented)	Must support a 1280-byte packet size (without fragmentation)

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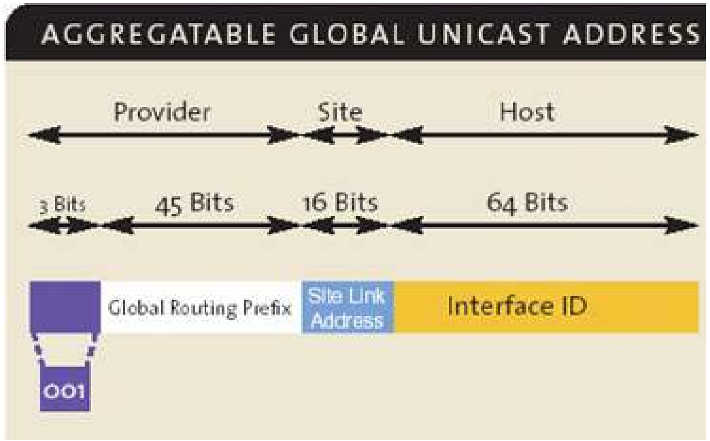
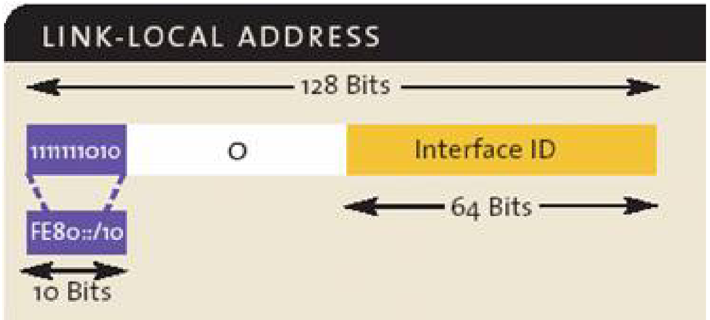
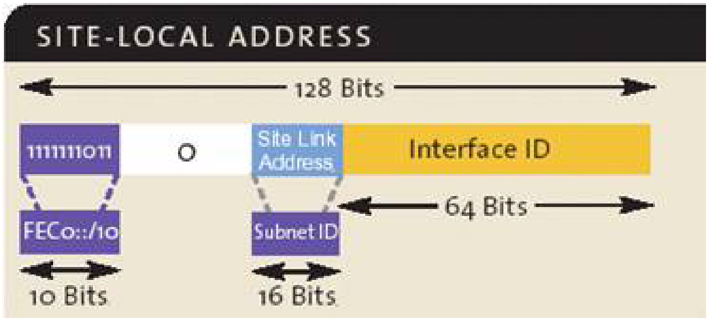
IPv6 Address space
Unicast

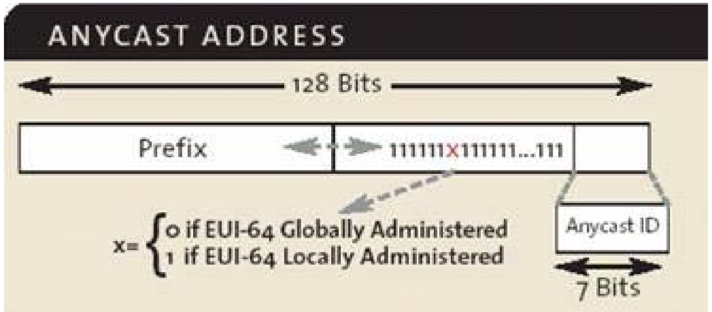


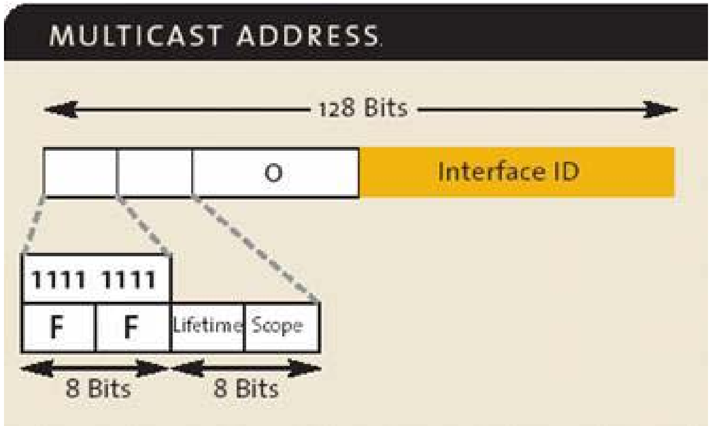




Courtesy of Cisco Systems

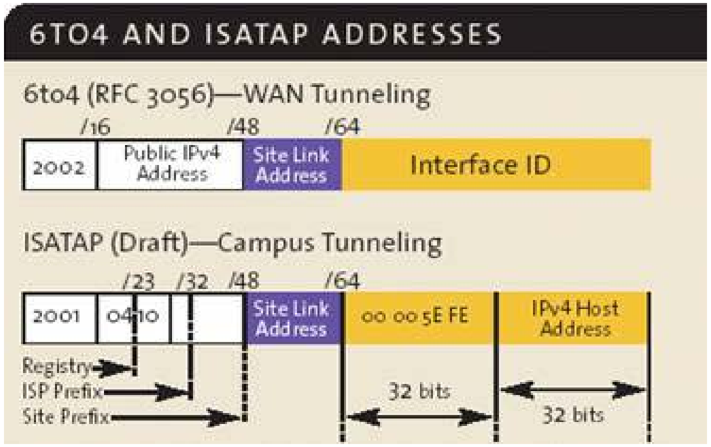
IPv6 Address space
Multicast





Courtesy of Cisco Systems

IPv6 Address space Loopback and IPv4



Courtesy of Cisco Systems

IPv6 Products (October 2002)

- Many open source SW IPv6 products exist at this time
- Microsoft: Windows XP, Server 2003 and CE
- Cisco: IOSA 12.2.(2).T +
- Juniper 5.2 Internet Software
- Sun: Solaris 8.0 +
- SCO: Unixware 7.0 +
- HP: HPUX 11i + and Tru64 5.1+
- IBM: AIX 4.3 +
- Apple: OS 10.2
- Symbian OS
- Checkpoint Firewall
- 802.11b wireless devices

IPv6/IPv4 Coexistence Mechanisms

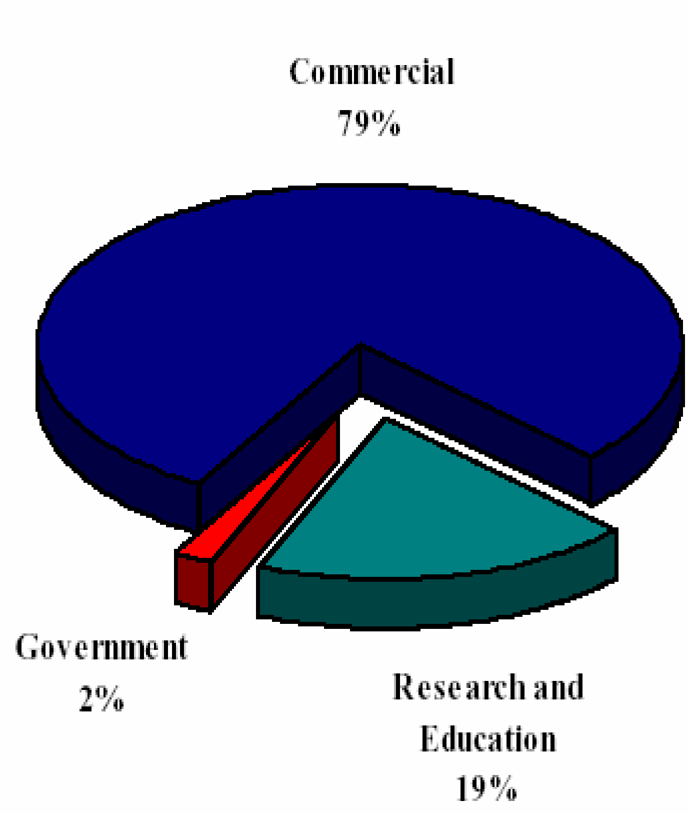
- Dual Stack
- BITS
- BIA
- SOCKS
- SIIT (Note 2)
- NAT-PT
- TRT
- 6over4
- ISATAP
- DSTM
- Teredo (Note 2)
- Configured Tunnels
- Automatic Tunnels
- 6to4 (Note 2)
- BGP Tunnel

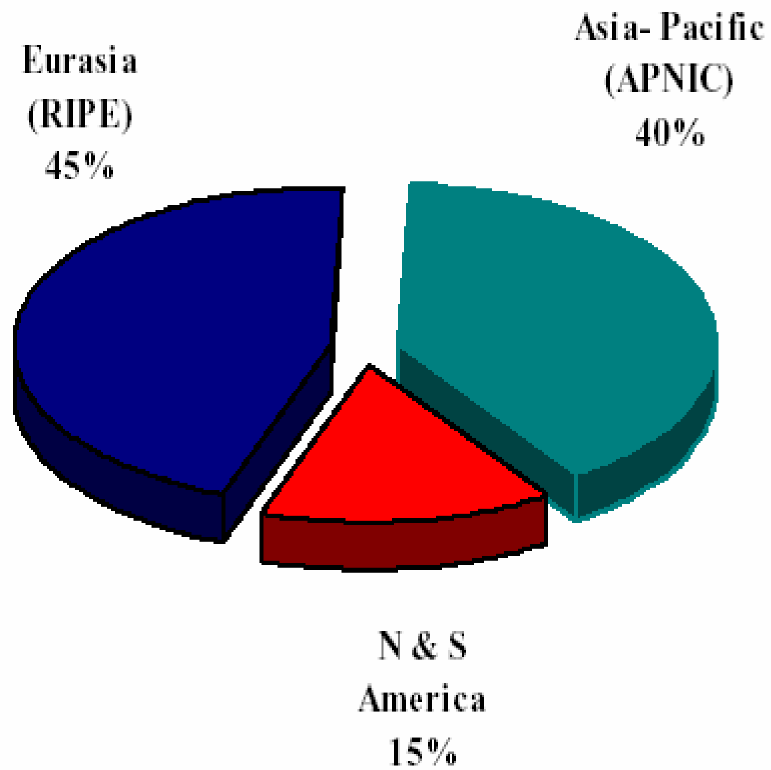
Note 1 – Some CMs are useful standalone, some in combination, some CMs must be used in combination, some are targeted for home use and not the enterprise and some CMs are more mature than others.
Note 2 – CMs having dedicated IPv6 address prefixes.

Where IPv6 is Used Today

- Countries that did not get in on the "address-space grab" when the Internet first grew
- Less frequently used in the US since addresses are still available from most ISPs

Distribution of Production IPv6 ISPs





Current IPv6 Deployment

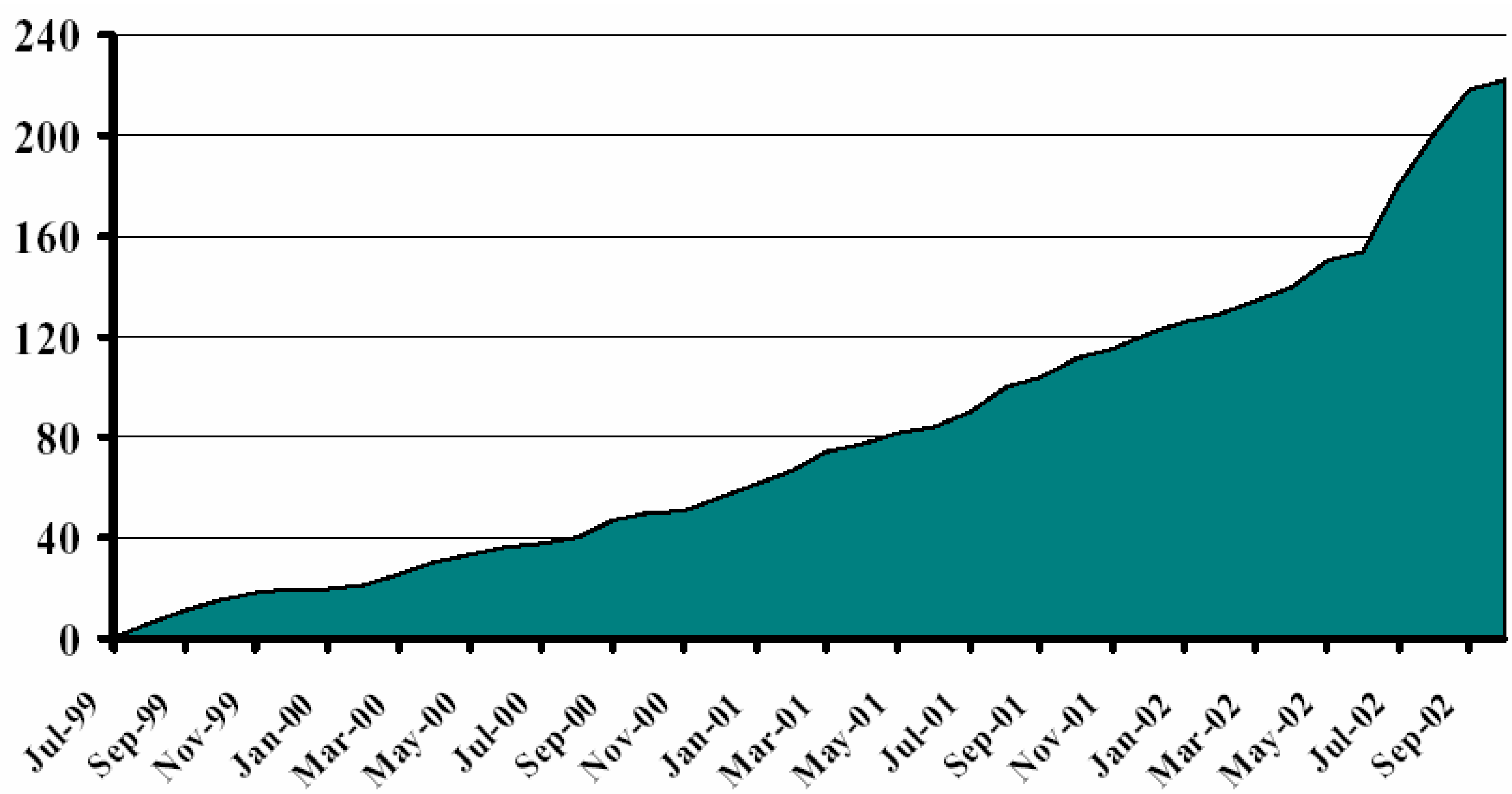
#	Country	ISPs
1	Japan	47
2	US	24
3	Germany	20
4	South Korea	14
5	UK	8
6	Netherlands	7
7	Europe	6
8	Austria	6
9	France	6
10	Taiwan	6
11	Mexico	5
12	Finland	5
13	Italy	5
14	Canada	4
15	Sweden	4

#	Country	ISPs
16	Norway	4
17	Poland	4
18	Switzerland	4
19	Australia	4
20	China	4
21	Portugal	3
22	Singapore	3
23	Thailand	3
24	Russia	2
25	Ireland	2
26	Spain	2
27	Lithuania	2
28	Denmark	2
29	Malaysia	2
30	Brazil	1

#	Country	ISPs
31	Luxembourg	1
32	Greece	1
33	Belgium	1
34	Czech	1
35	Hungary	1
36	Estonia	1
37	Cyprus	1
38	Yugoslavia	1
39	Turkey	1
40	UAE	1
41	Papua New Guinea	1
42	India	1

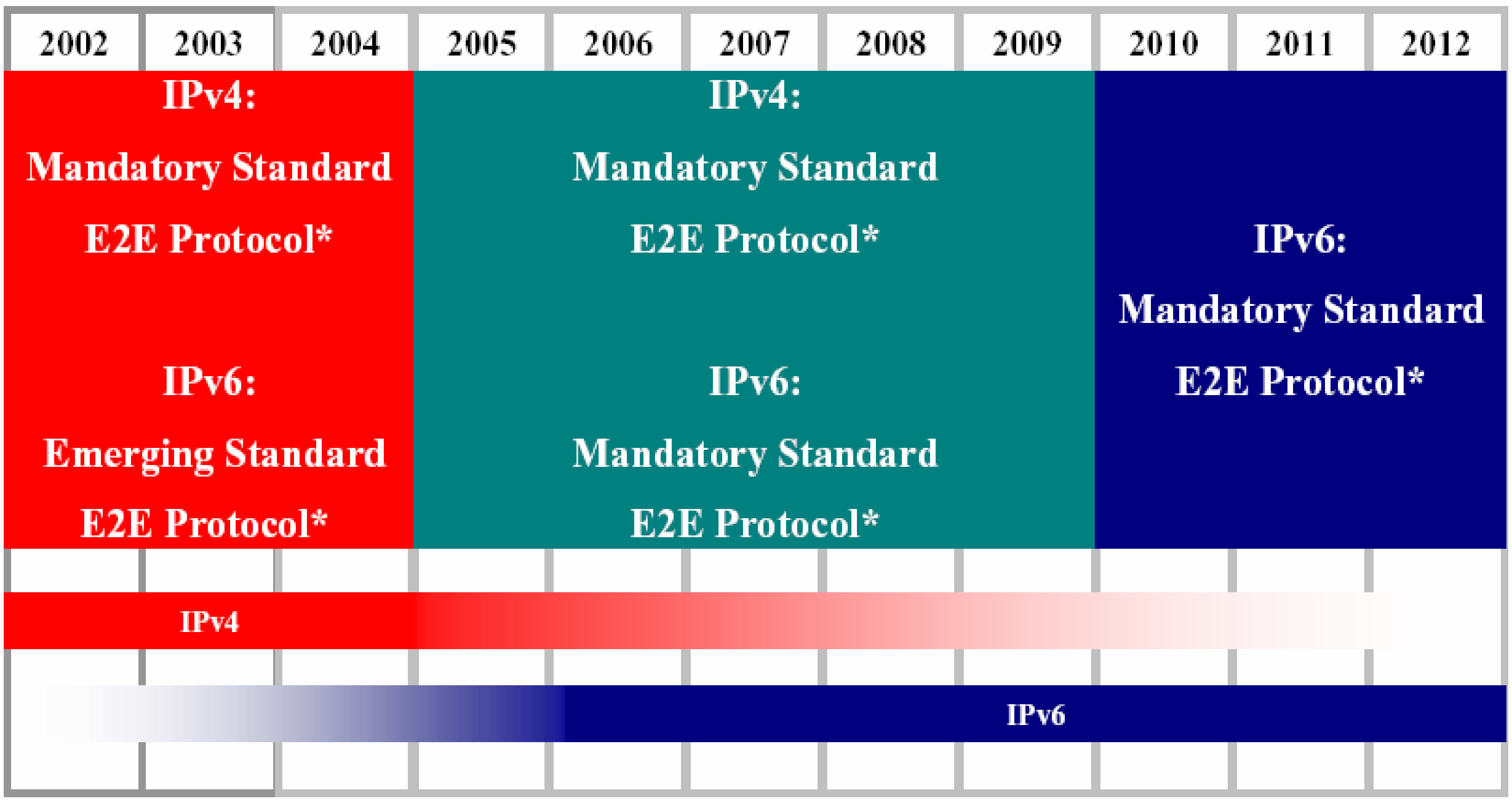
129 pTLAs in 56 nations (6BONE)

222 ISPs in 39 Months



IPv6 Internet demonstrates the trend of doubling in size every year.

DOD IPv6 Deployment Timeline



ngi.spawar.navy.mil

Why Aviation Needs IPv6

- Expected number of aircraft using IP Air-Ground communications in the next 25 years is over 100,000
- Each aircraft is expected to contain one or more subnetworks
- IPv6 is scalable to large networks
- Long life cycle for aviation equipment leads to adopting IPv6 early

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IPv6 Usage for Aviation

- As an option for ACARS transport
  - Air-Ground
  - Ground Network (Can be tunneled over IPv4)
- As an enhancement to the Aeronautical Telecommunications Network (ATN)

IPv6 as New Platform for Growth of the Aeronautical Telecommunications Network (ATN)

- OSI protocols have failed to gain acceptance
- Lack of commercial OSI products and affordable ground-based equipment and software
- IPv6 can coexist with OSI in the ATN

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ATN OSI Issues

- Security not standardized in OSI
- No native mobility mechanism
- No reliable multicast
- Limited scalability

IP is Used by ATN Today

- Ground-Ground ATN Network supports IP today using a Subnetwork Dependent Convergence Function (SNDCF) today
  - X.25 networks are being phased out so this solution became necessary
- A scheme can be developed for the Air-Ground Network

IPv6 and OSI

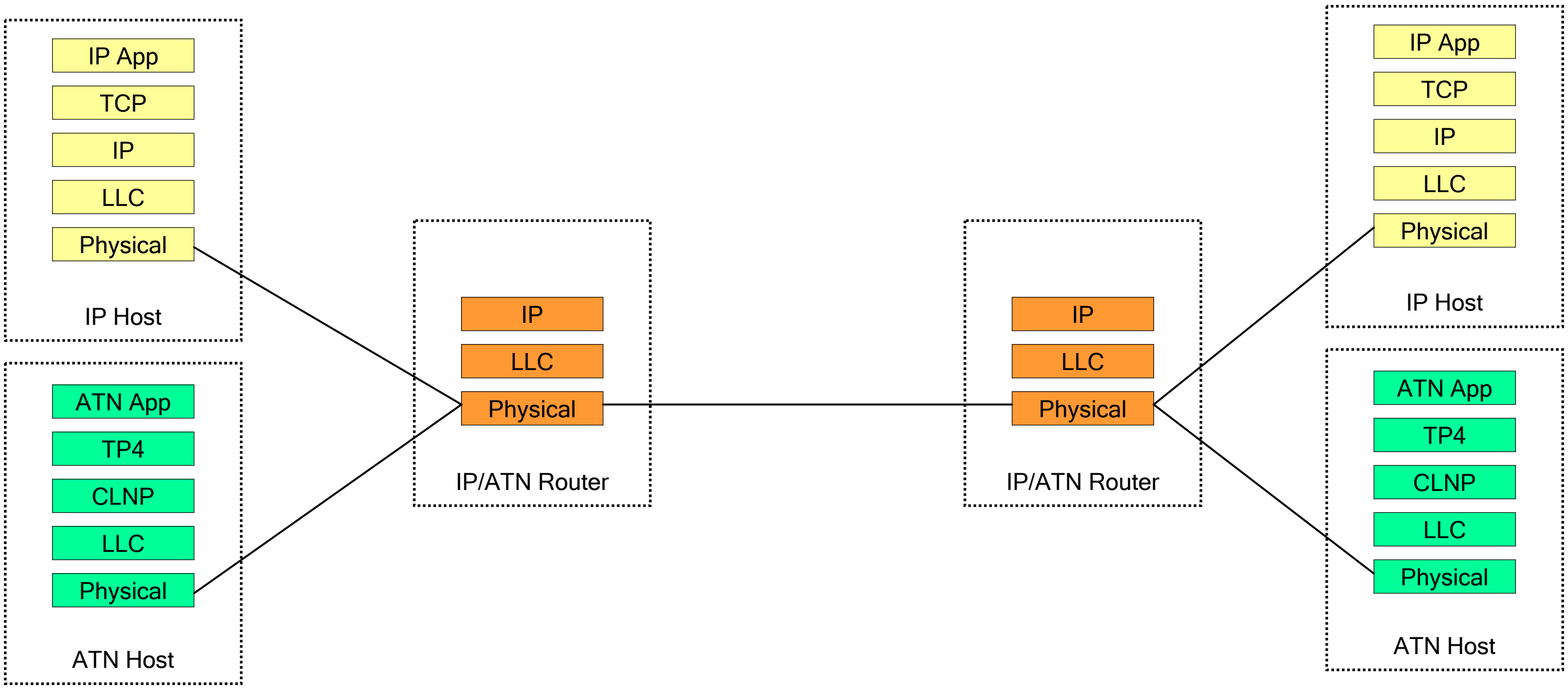
- IPv6 addresses support standard OSI addresses (IPv4 addresses are too small)
- IPv6 Options using Header Extensions can be used to create any missing OSI functions and ATN extensions to OSI

IPv6 ATN Options

- Coexistence of OSI and IPv6 protocols
  - Multi-protocol routers and networks
  - Layer 2 Air-Ground mobility or dual mobility schemes
- Native use of IPv6 in G-G and A-G Networks
  - Tunneling of OSI protocols in IPv6 packets
  - Translation of OSI packets to IPv6 packets
  - Either achieved using
    - A gateway (“bump in the wire”)
    - Host protocol stack changes (“bump in the stack”)

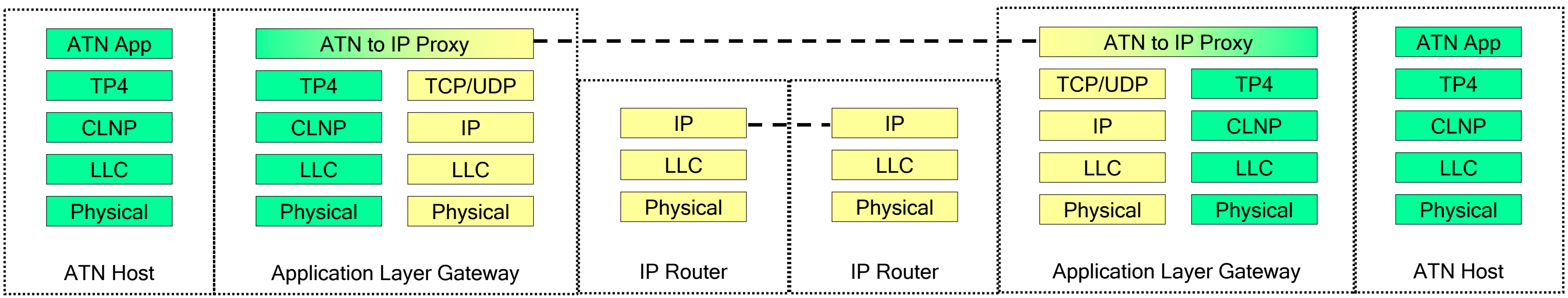
Multi-protocol Routers

(Ships-in-the Night)



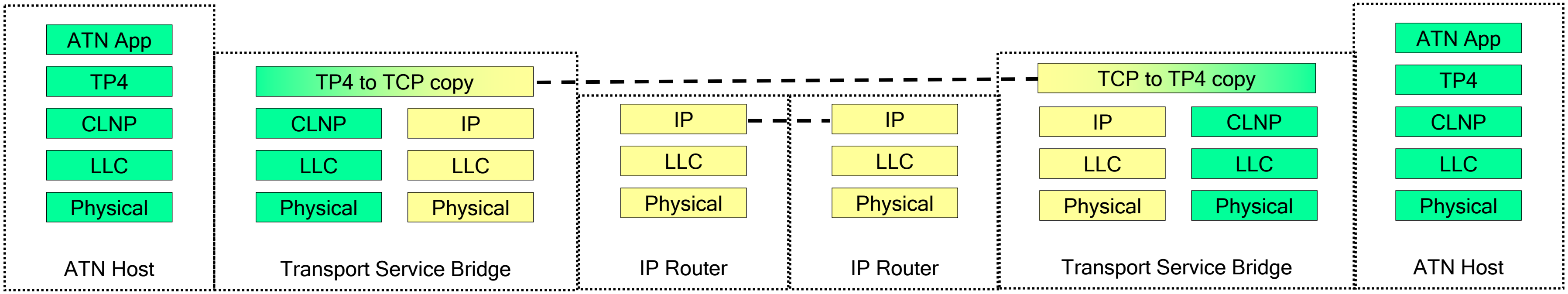
Application Layer Gateway

Layer 7



Transport Service Bridge

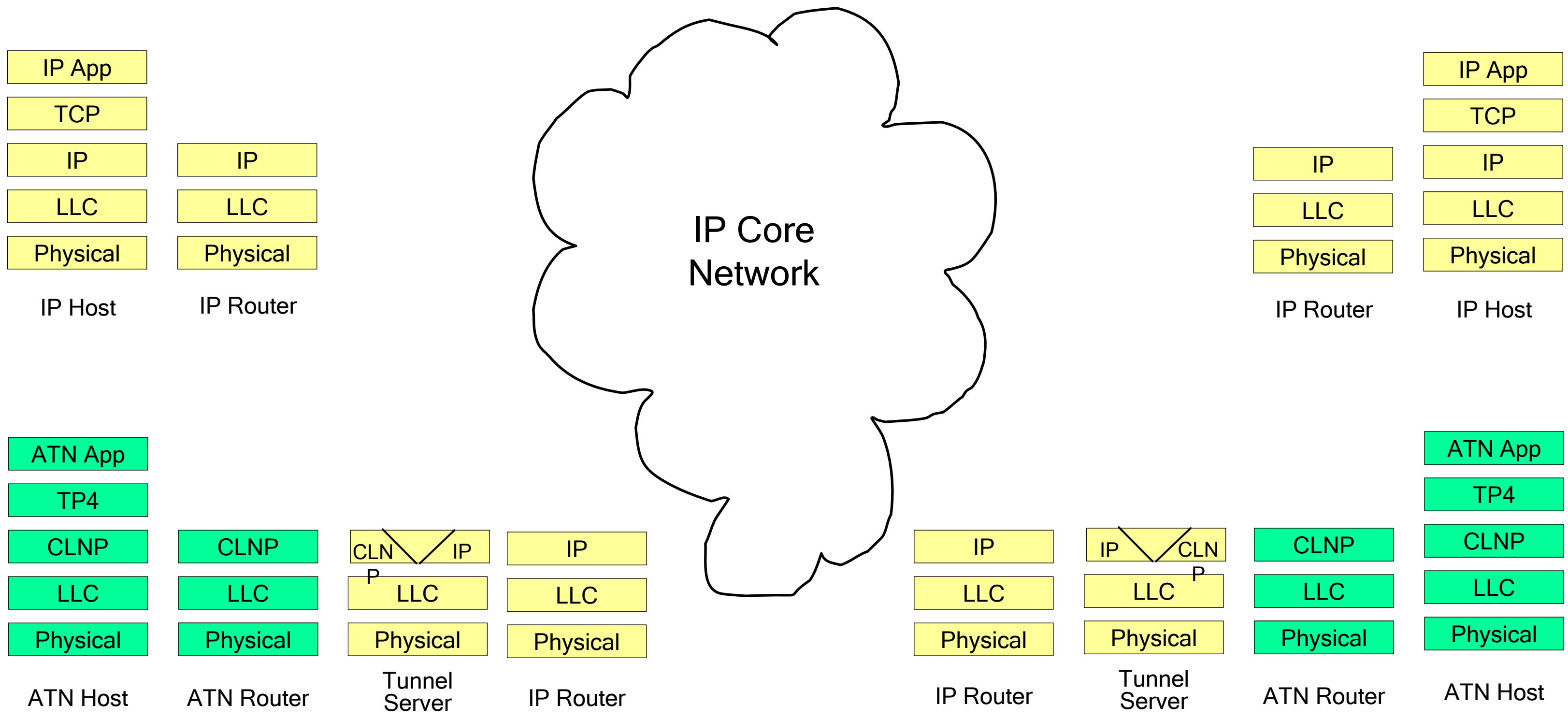
Layer 4



Encapsulation Tunneling

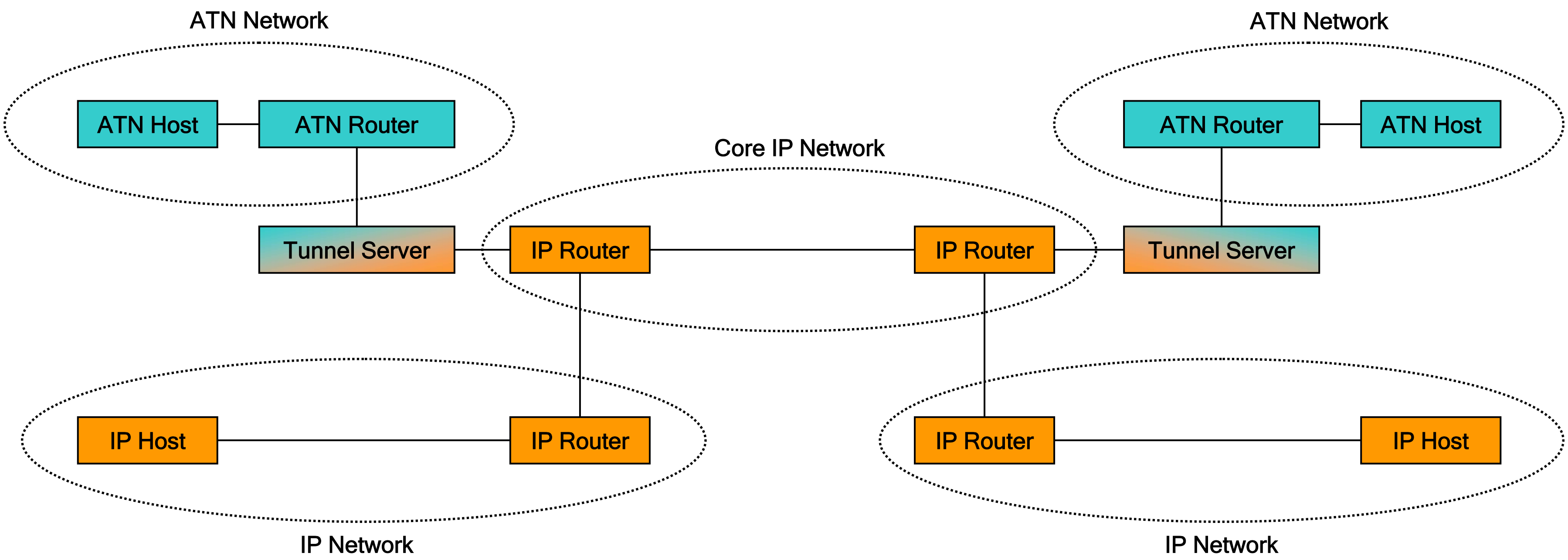
Layer 3

(IPv6 Generic Packet Encapsulation)



ATN Packet Tunneling over IPv6

(Example of Encapsulation Tunneling)



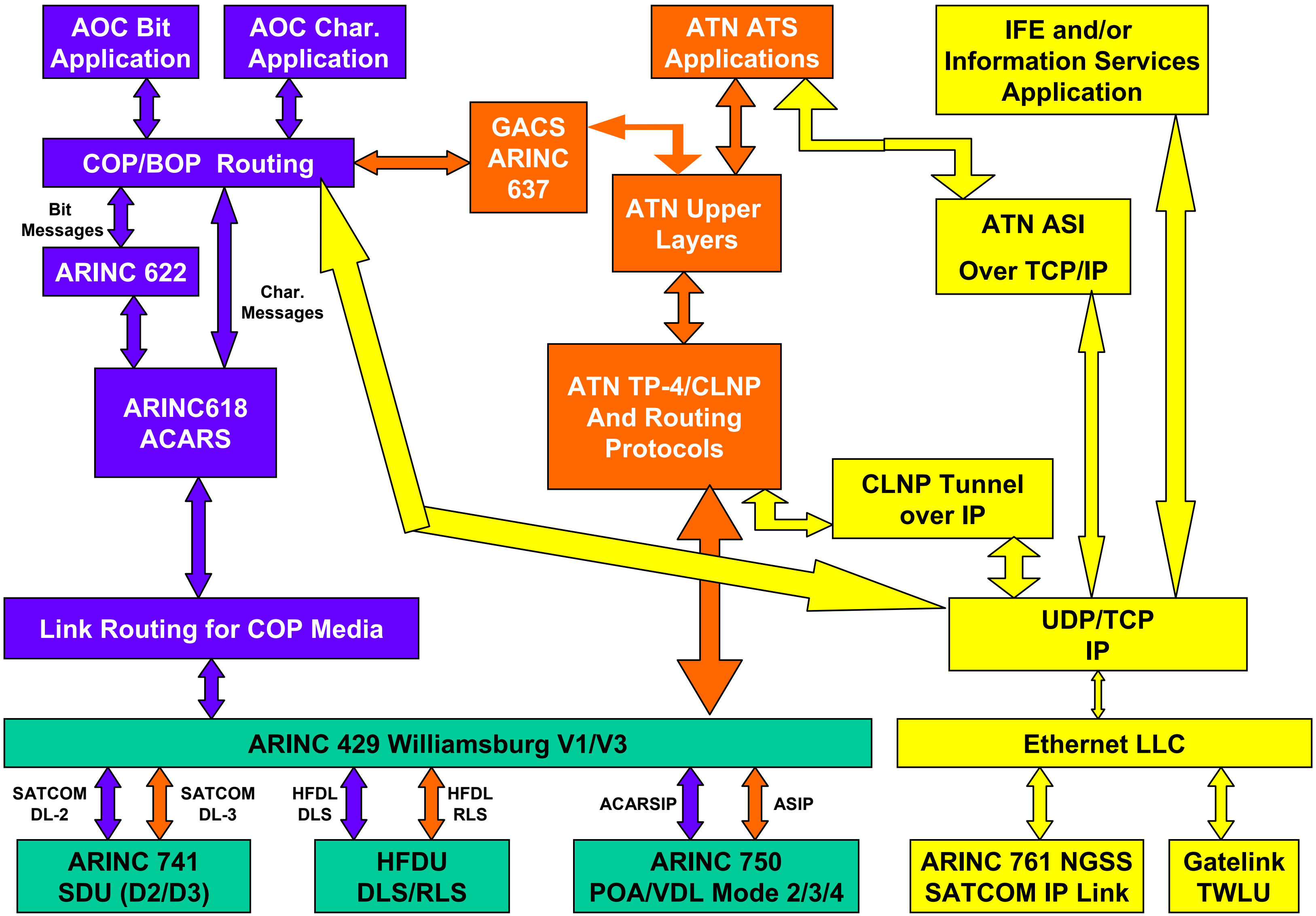
Challenges for IPv6

- Mobility mechanism that meets ICAO ATN requirements:
  - Concurrent use of multiple data links
  - Geographically distributed redundancy in ground network
- Mobility for IPv6 today is Mobile IP, based on a “home agent” approach
  - ATN traffic flows through a “home routing domain” in some situations
- New mechanisms for mobility are currently being worked in the IETF (NEMO)

ACARS/ATN/IP Avionics Protocol Architecture

- Assumptions:
  - Next Generation Satellite Services (NGSS) uses TCP/IP protocol
  - Existing AOC applications remain unchanged
  - ACARS will co-exist with ATN and IP datalinks
  - HFDU, SDU and VDR can support both ACARS and ATN data flows. How data is differentiated is an implementation issue
- Data Flows:
  - Blue indicates existing ACARS functions and ACARS data flow
  - Red indicates ATN enhancements and ATN data flow
  - Yellow indicates TCP/IP enhancements and related data flow
  - Two alternatives exist to transfer ATN data over TCP/IP:
    - One is to provide a direct ATN Application Services Interface (ASI) over TCP
    - Another is to tunnel CLNP data over IP network whereby IP acts as an ATN compliant subnetwork such as VDL
  - AOC data is sent over ATN using GACS specified in ARINC 637
  - AOC data can be sent directly over UDP/TCP/IP networks

ACARS/ATN/IP AVIONICS PROTOCOL ARCHITECTURE



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Produced for ARINC 664 (with Aloke Roy - Honeywell)

ACARS/ATN/IP Avionics Protocol Architecture

- **List of Acronyms:**
  - ACARS: Aircraft Communications Addressing and Reporting System
  - ACARSIP: ACARS Interface Protocol
  - ADN: Aircraft Data Network
  - AOC: Airline Operational Control
  - ASI: Application Services Interface
  - ASIP: AVLC Simple Interface Protocol
  - ATN: Aeronautical Telecommunications Network
  - ATS: Air Traffic Services
  - BOP: Bit Oriented Protocol
  - CLNP: Connection-Less Network Protocol
  - COP: Character Oriented Protocol
  - DLS: Data Link Service
  - HFDU: HF Data Unit
  - GACS: Generic ATN Communication Service
  - IFE: In-Flight Entertainment
  - IP: Internet Protocol
  - LLC: Logical Link Control
  - NGSS: Next Generation Satellite Services
  - POA: Plain Old ACARS (implying existing ACARS mode of operation)
  - RLS: Reliable Link Service
  - SDU: Satellite Data Unit
  - TCP: Transmission Control Protocol
  - TP-4: Transport Protocol Class-4
  - TWLU: Terminal Wireless LAN Unit
  - UDP: User Datagram protocol
  - VDL: VHF Digital Link
  - VDR: VHF Digital Radio

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Improving performance by developing solutions based on applied technology and the underlying process and relationship elements in the entire value chain